
UNIVERSITY of HOUSTON | UH ENERGY
HYDROGEN
2020–2021 | Energy Symposium Series | Critical Issues in Energy
FRIDAY, OCTOBER 23RD 2020 | 10:00AM – 11:30AM CST
VIRTUAL SYMPOSIUM

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Chief Energy Officer

UH Energy

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“Houston: Low-Carbon Energy Capital –
Four Ways Forward” series visit:

https://uh.edu/uh-energy/energy-symposium-series/low-carbon-energy-capital/

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Why Houston Will Be the Capital of a Low Carbon Energy World: **Becoming a Global Hydrogen Hub**

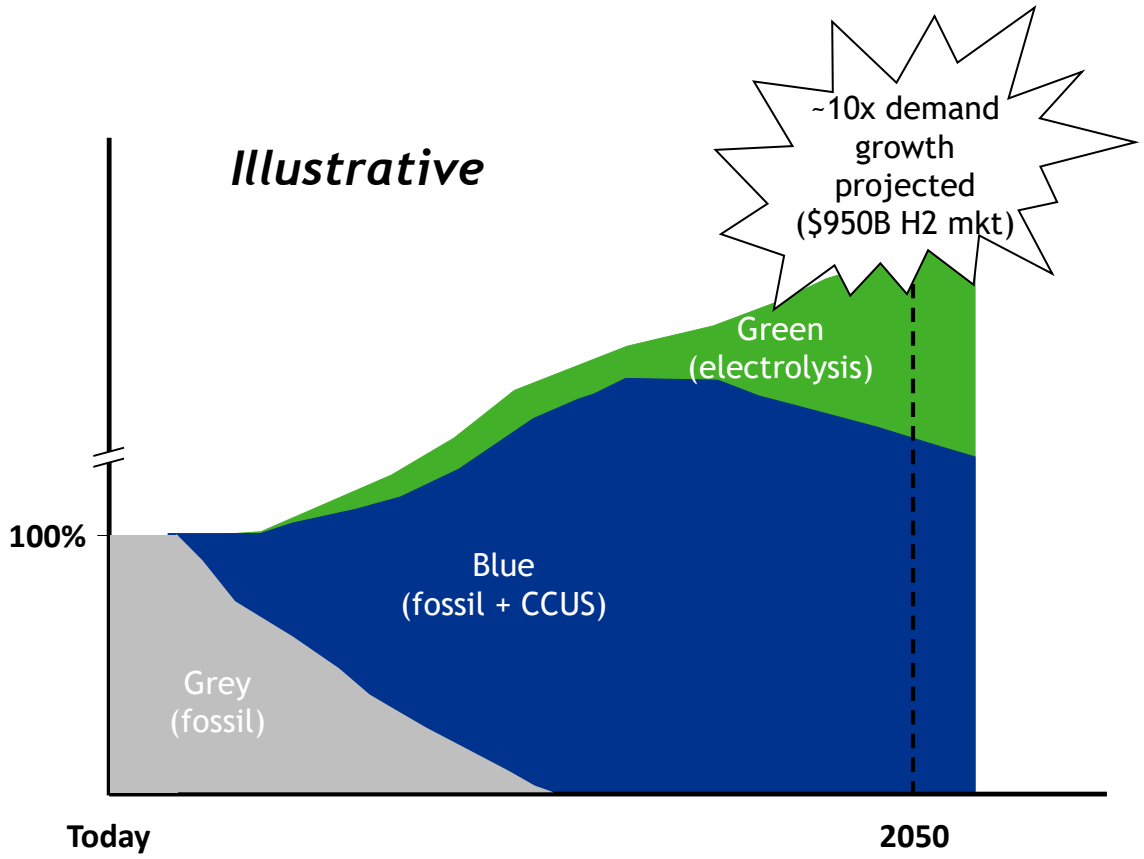
Matt Hoffman, Zujajah Fatima, Katherine Nguyen

KPMG / CHF working team: Andy Steinhubl, Todd Blackford, Josh Gresham, Brett Perlman

October 23, 2020

Decarbonization is catalyzing rapid H2 market expansion, and strategies are emerging to capture the opportunity

Hydrogen demand and mix over time



Source: Barclays, HSBC, Hydrogen Council

Localized Drivers

- Goals: 2050 net zero or similar
- Funding: Carbon fees or other
- Leverageable assets (blue)
  - H2 system
  - At-scale CCUS hub
- Leverageable assets (green)
  - Geologic storage
  - Low power prices

Cross cutting Enablers

- Cost and supply chain improvements
  - Electrolyzers
  - Renewables
- H2 and renewable synergies

Our project sought to develop a customized roadmap to scale clean H2 in greater Houston

Project approach & methodology

- How can Houston most economically expand the role of H2 in the energy system?
  - Assimilated decarbonization country and regional strategies
  - Assessed project case studies across the value chain
- What blue and green value chains offer the greatest activation advantages?
  - Leveraged multiple market studies
  - Conducted targeted analyses (e.g., heavy trucking economics, electrolysis/storage)
- How might H2 scale in Houston? What role might be played beyond Houston? What roadmap might be followed?
- How can this potential be operationalized and progressed? With whose involvement?

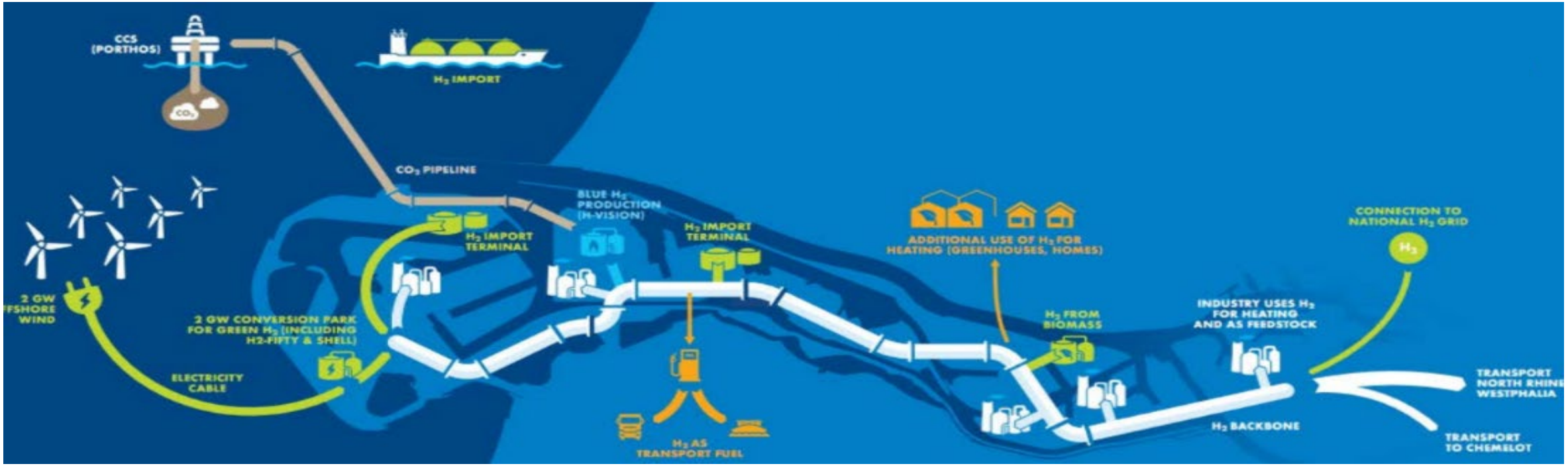
Key contributors

Key Findings

- Global decarbonization momentum is growing, catalyzing substantial global H2 market expansion of $800 billion by 2050, as part of H2 gas plus related technologies market of $2.5 trillion
- The Houston area is poised to lead H2's growth in the energy system
  - World leading existing H2 system positioned to bring H2 to market, at-scale, quickly
  - Opportunity to create a green H2 industry over time by leveraging significant low-cost renewable power and storage synergies
- There are four immediate initiatives to launch Houston area blue and green H2 market opportunities, leveraging scale , cost and other advantages:
  - Launch heavy trucking
  - Clean existing H2 system (via CCUS)
  - Exploit seasonal cavern storage
  - Pilot long duration storage to support deeper renewable penetration
- The Houston area has the potential to become a local, national, and global flywheel for H2 penetration into heavy industrial markets
- Kick starting the H2 economy and exploiting Houston's advantages to globalize its leadership in H2, becoming a global H2 hub, will require targeted policy and funding commitments be made

Notes: CCUS refers to carbon capture, usage, and storage

As an example, Rotterdam is transforming from a global O&G to hydrogen hub, following a grey to blue to green pattern



From - energy hub of today…

- Refining hub
- European gateway and logistics point
- Global market clearing point (e.g., refined products, bunker fuel)

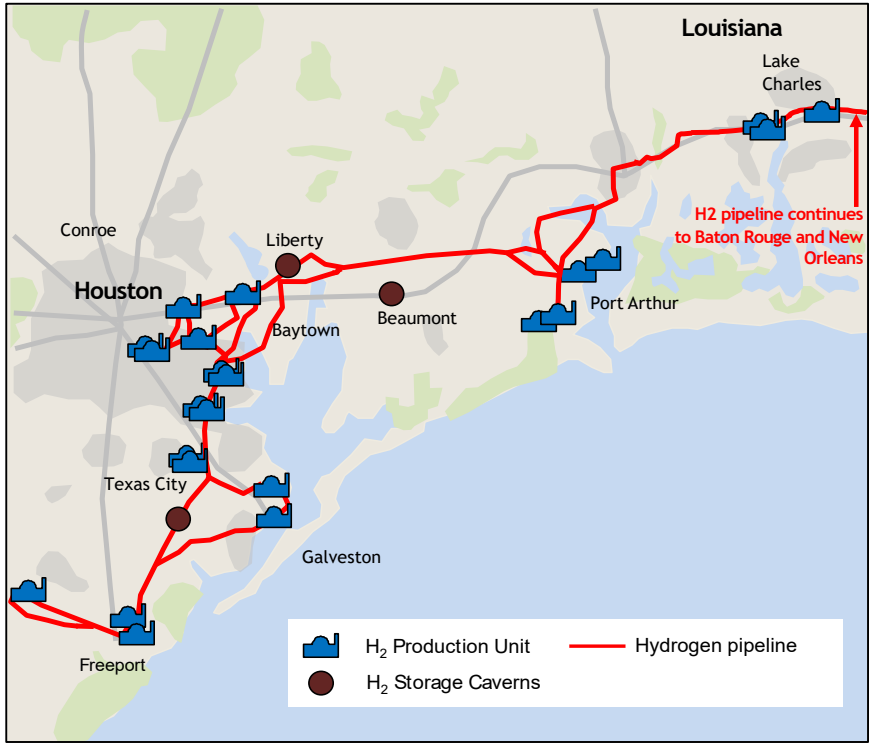
To - energy hub of tomorrow…

- Clean (blue and green) H2 production hub
- H2 gateway and logistics point with Northwest Europe
- Trading market for H2 with pricing transparency

Source: Rotterdam Vision

The Houston area anchors a world leading H2 system, with the key attributes to rapidly scale clean H2

Existing hydrogen system in the Gulf Coast area



*** Existing H2 system could leverage in-place CCUS assets (e.g., Denbury pipeline) to readily add and scale CCUS to convert grey to blue H2*

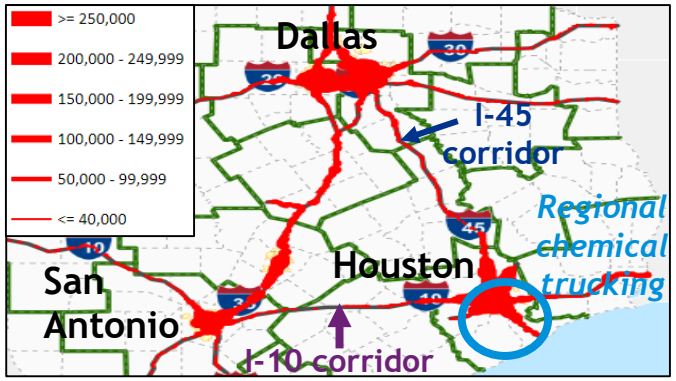
TX Gulf Coast H2 system advantages[1,2,3]

- **Over 900 miles H2 pipelines (56% of US; 32% of global)**
- **~3.4MMt of H2 produced annually largely through steam methane reformation (34% of US; 8.5x Rotterdam)**
- **48 H2 production plants**
- **World's largest storage caverns for H2; adjacent to H2 network**

Notes: (1) Houston MSA defined Austin, Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery and Waller counties; (2) TX Gulf Coast includes a region from Corpus Christi, TX to Lake Charles, LA; (3) Number of global H2 plants estimated by dividing global H2 production by US avg. production per H2 plant (52k tons H2 / year)
Source: H2Tools; USDOT PHMSA - National Pipeline Mapping System; Seeking Alpha; Office of US Energy Efficiency & Renewable Energy; Hydrogen Europe

In the near-term, the existing system can be leveraged to kick-start the H2 economy by using H2 in heavy duty trucks

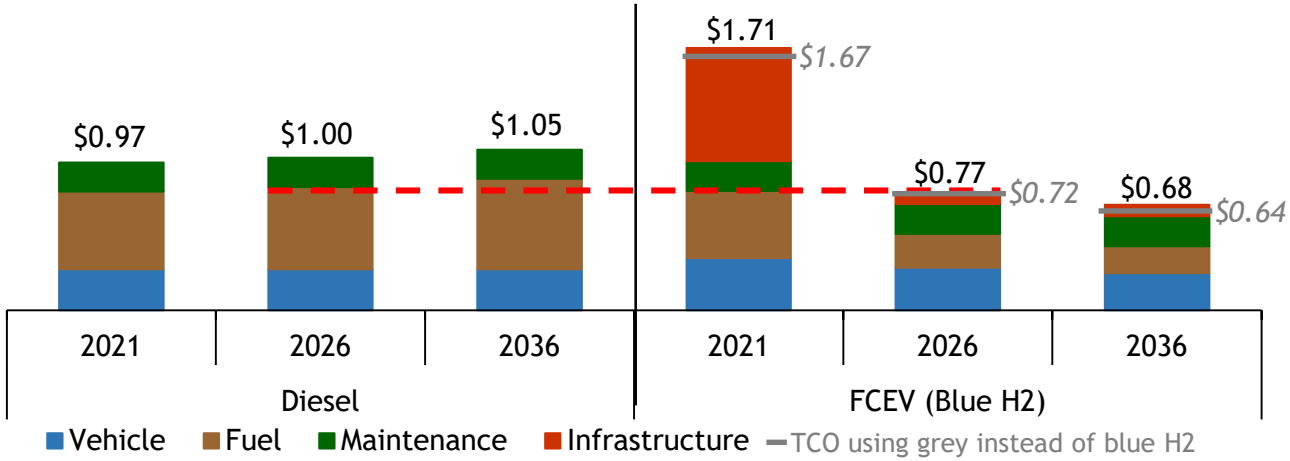
Texas truck traffic, 2018



Several local and regional heavy trucking markets

- I-45: offers long-haul advantage over BEVs and potential to link Dallas / central US distribution hub
- I-10: offers long-haul advantage over BEVs and potential to synergize with P/L to tap CA LCFS market
- Regional trucking: potential easier demonstration, though BEV may be advantaged for shorter trips where payload/capacity less of focus

Total Cost of Ownership, diesel and H2 HDVs on I-45, $M/truck[1,2]

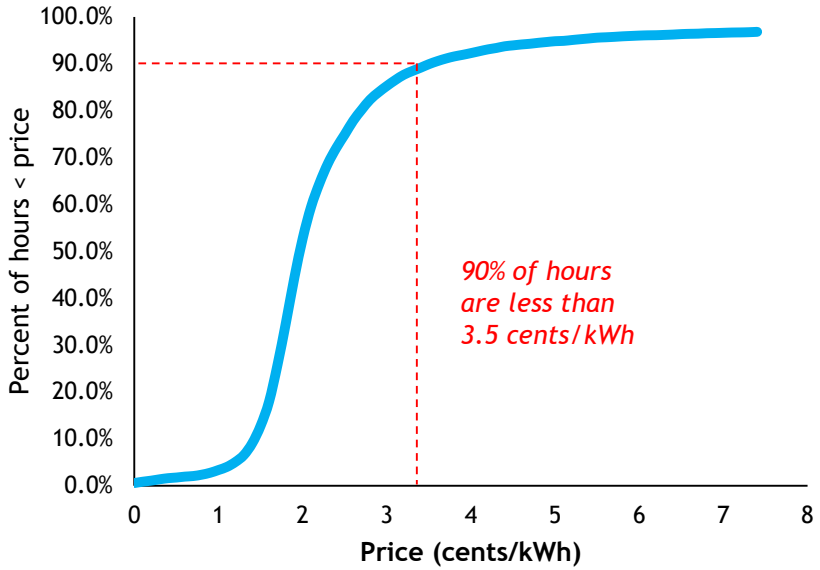


- Lower H2 (SMR) TCO:
  - Low H2 cost
  - Increasing diesel costs
  - Infrastructure scale economies
- ~15% well to wheel emissions reduction for grey H2 vs. diesel

Notes: (1) 115,620 annual miles driven; (2) station utilization: expand: 50%, rollout: 60% (3) pilot, expand and rollout phases last 10 yrs ea.; (4) YoY H2 truck capex reduction follows three phases (4%: '20-'25, 2.1%: '25-'30, 0.6% ea. yr. afterward)
Source: ANL: HDSRAM, EIA, KPMG analysis, ICCT: Infrastructure needs and costs for zero-emission trucks

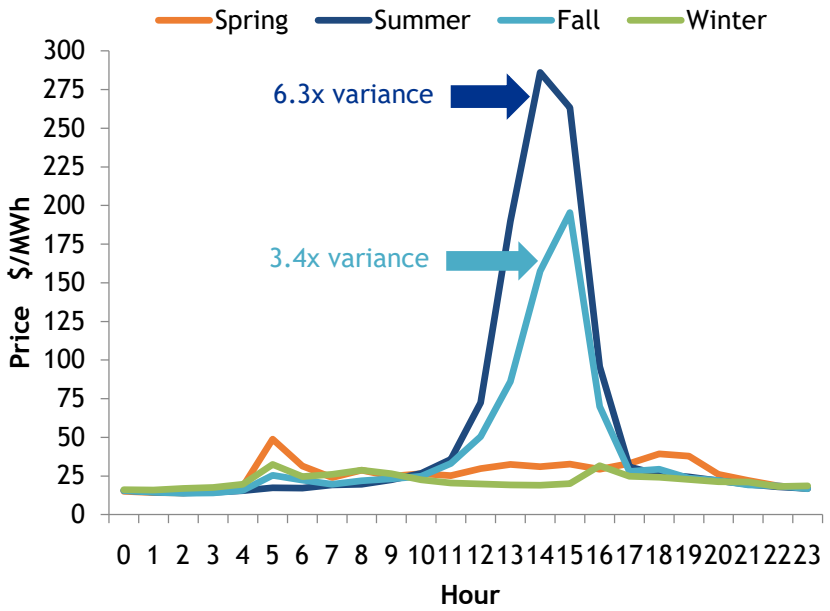
Additionally, TX has multiple advantages that could improve green H2 economics, supporting a green industry build out

Houston wholesale price duration curve, 2019



- Low cost generation and competitive market structure
- Extensive and growing renewables (#1 wind, #2 solar by '25), increasing long-duration storage role

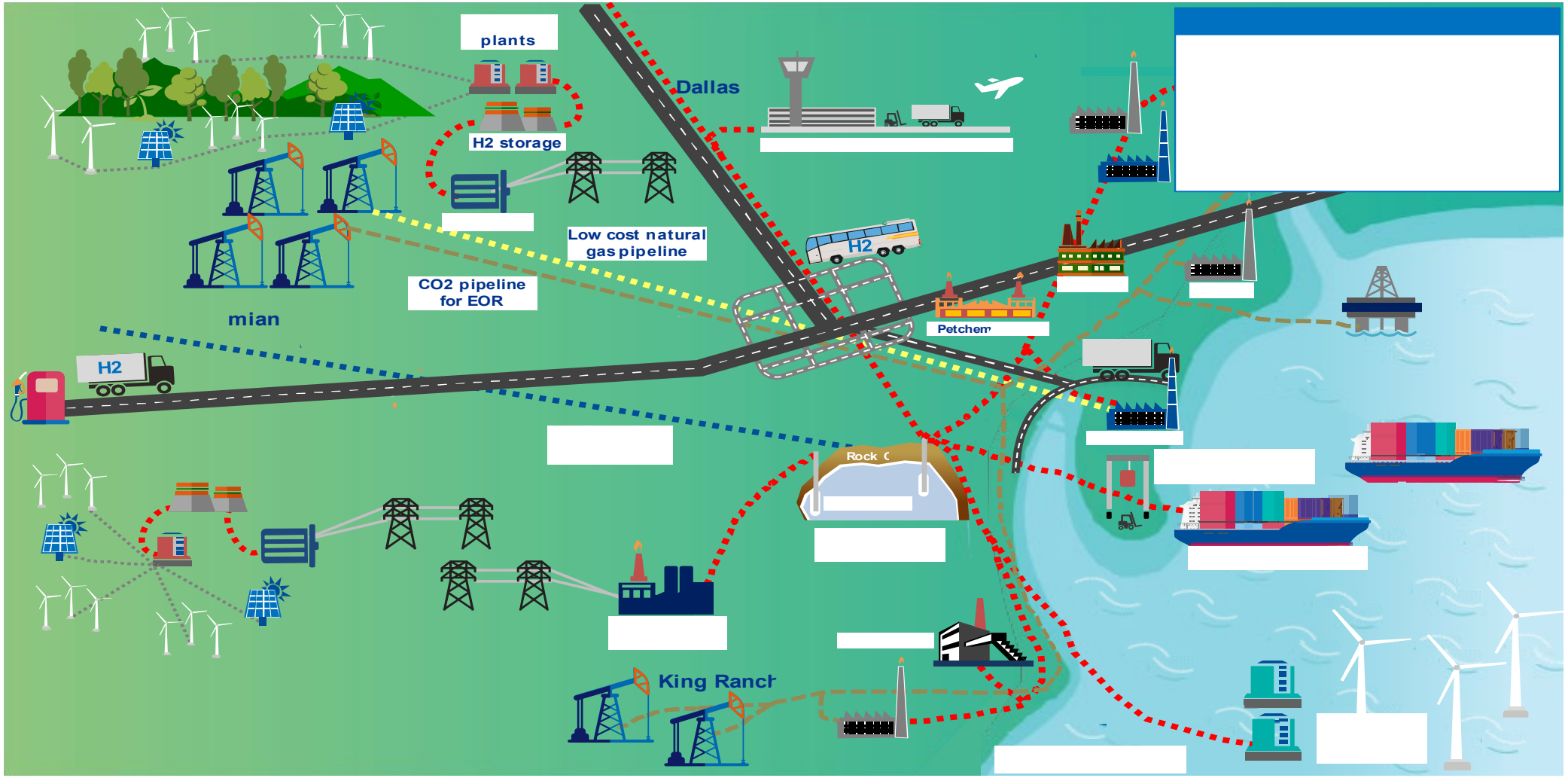
Average Houston hub wholesale power price, 2019[1]



- High seasonal price differentials, coupled with low cost storage, enhances storage economics

***Market insights and electricity price data provided by S&P Global Platts*

Potential Houston ‘2050 vision’: local, national, and global flywheel for H2 penetration into heavy industrial markets



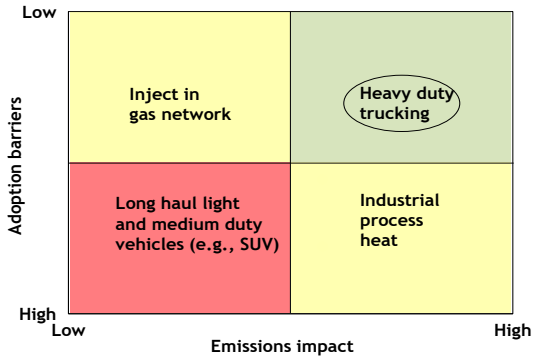
Four immediate initiatives, with targeted policy/funding, will activate Houston's H2 growth potential

Activate

Launch heavy trucking

- Assemble coalition(s)
- Select and optimize market(s)
- Develop roadmap

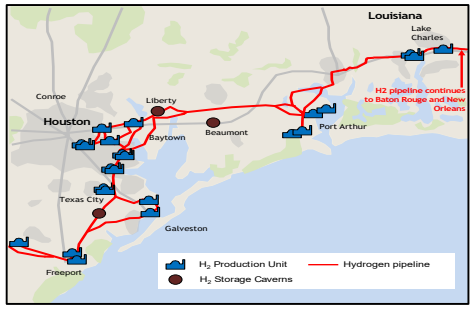
Prioritization of blue markets



Clean grey system

- Assemble coalition
- Develop CCUS expansion plan

Existing TX H2 system

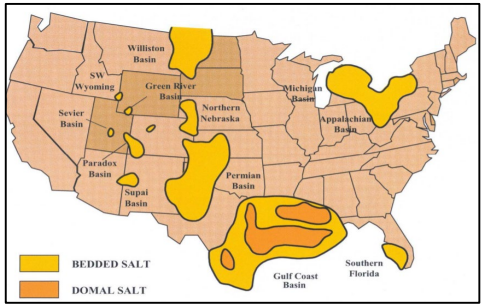


Activate

Exploit seasonal storage

- Evaluate commercial options to leverage Houston's salt caverns

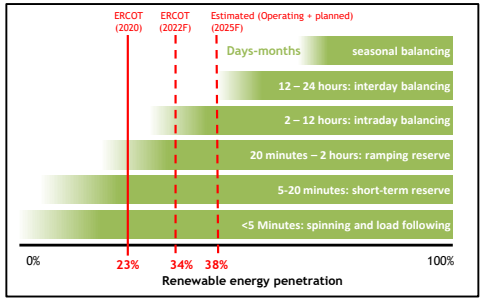
US salt cavern storage



Pilot long duration H2 storage

- Assess H2 storage fit

Storage required by renewable penetration



Policy and funding

- Develop policy/funding approach, which unleash new attractive market opportunities, near and longer term

Notes: (1) PUC refers to Public Utility Commission

Beyond activation, a customized roadmap provides a phased approach to globalize Houston's hydrogen leadership

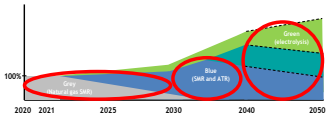
Global hydrogen hub

	Activate 2020 - 2030	Expand 2030 - 2040	Rollout 2040 - 2050?
Production	• CCUS for priority H2 plants (8) • H2 seasonal and long duration storage pilots	• CCUS for remaining H2 plants (40) • Expand blue for export • Extend green synergistically with renewables	• Scale offshore wind and electrolyzer production
Markets	• Heavy trucking pilots (grey H2) • Expand H2 trucking infrastructure	• Export to advantaged markets (e.g. CA for LCFS) • H2 for transit buses; decarbonize gas-fired power	• Use low cost H2 to decarbonize industrial processes
Investment[1,2]	**$600M - $900M**	**$1,700M - $8,500M**	**TBD**

Increasing investment and policy support required

Grey H2 — Blue H2 — Green H2 — Potential for blue/green H2

Houston hydrogen production mix over time



Benefits

- Capture new H2 markets created globally
- Further diversify Houston economy and create new jobs
- Progress decarbonization (15.4 Mt CO/year reduced by 2050)
- De-risk / mitigate carbon impact of heritage refining and petchem industry

Notes: (1) Activate costs assume 50% stretch case investment; (2) 5x stretch case added to investment for expand phase to account for excluded costs (i.e., new blue plants, new green storage applications,); (3) Reduction in Co2 emissions refers to converting trucking to blue H2, buses to green H2, and adding CCUS to existing H2 plants

Acknowledgements

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UH / KPMG working team: Matt Hoffman, Zujajah Fatima, Katherine Nguyen, Andy Steinhubl, Todd Blackford, Josh Gresham

Thank You!

Submit your Q&A questions
now for Andy Steinhubl at:

uh.edu/energy/ask

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Date to be announced for the next event:

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